Addressing self-disconnection among prepayment energy consumers: A behavioural approach

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Abstract

This paper explores links between self-control in decision-making and self-disconnection by households using energy prepayment meters. Self-disconnection happens when households exhaust all available credit in their meter and are left without a supply of energy because they have been unable to top-up. This has serious consequences for the well-being of households and also increases firms' costs. We explore behavioural characteristics associated with self-disconnection and present saving plans to help households minimize self-disconnection. We show that, in our sample, stated self-disconnection is positively associated with lower levels of goal achievement. We also show that households which have already experienced self-disconnection are more likely to accept an energy savings plan. It is relevant and promising that these households tend to select saving plans most likely to minimise their likelihood of self-disconnection. Our findings give some useful insights for energy policy-making, both for policy-makers interested in alleviating energy poverty and for energy utilities keen to limit self-disconnection.

Keywords: Prepayment meters, Household finance, Goal achievement, Self-disconnection

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1. Introduction

Research in economics and psychology suggests that many important choices involve inter-temporal trade-offs between immediate and delayed costs or benefits. In order to evaluate such trade-offs, decision-makers compare the costs and the benefits of outcomes occurring at different times. However, people can be impatient in the sense that they tend to prefer to enjoy immediate rewards and to defer costs.[6]

Prepayment metering is an interesting case to study these inter-temporal trade-offs. This type of metering requires the energy payment to be made before actual consumption takes place; that is, households have to pay for electricity and/or gas (immediate costs) before they consume it (the benefits are delayed). This allows for self-disconnection, which happens when a household exhausts all available credit, is unable to top-up and so is left without supply of energy, but without the energy utility actively disconnecting them for failure to pay their bills.

For some UK consumers, prepayment meters are combined with an emergency credit facility, so that vulnerable households can be protected from energy cuts at least for short periods of time e.g. a weekend. Nonetheless, self-disconnection can have serious consequences for the well-being of households. Lack of heating and associated health risks, especially for the vulnerable and elderly are a significant threat. In addition, there will be nutritional consequences if interrupted energy supply impairs food preparation, exposing the fuel poor to vulnerability from food poisoning. There will also be leisure and psychological impacts, associated with shame or loss of self-esteem (see ConsumerFocus (2010))[7] Likewise, self-disconnection gener-

[6]Strotz (1955) was the first to model impatience for near-term trade-offs rather than for future ones, modelling it as a commitment device, showing that, under exponential discounting, preferences are time-consistent, but under non-exponential discounting agents may prefer to constrain their own choices. See also Frederick et al. (2002), O'Donoghue and Rabin (1999), O'Donoghue and Rabin (2001).

[7]Self-disconnection is especially pronounced among low-income households and is associated with fuel poverty (Brutscher (2012), O'Sullivan et al. (2013)). In addition, fuel poverty has been regarded as a likely contributor to increased winter mortality rates (Rudge and Gilchrist (2005)). In defining what we mean by fuel poverty, here we use the Low Income High Cost (LIHC) relative definition of relative fuel poverty, which was introduced in England following Hills (2012) Review. By this definition, a household is fuel poor if it has lower than average income and higher than average fuel costs. For further discussion of fuel poverty indicators, see Moore (2012).

ates costs for the energy suppliers since it may contribute to lower energy consumption and higher costs associated with reconnecting of energy supply after self-disconnection.

Our paper explores two issues related to self-disconnection. First, we examine whether behavioural characteristics are associated with a propensity towards self-disconnection. Second, we propose energy savings plans designed to help households minimize their incidence of self-disconnection throughout the year. We then test empirically consumers' preferences for these plans. We explore whether households are willing to accept one of the designed saving plans and correlate these preferences with the households' behavioural characteristics.

Our empirical analysis is based around a survey conducted in collaboration with British Gas, designed and implemented across a sample of British Gas customers using gas pre-payment meters. The survey includes several questions related to behavioural characteristics. In particular, we have designed a question to assess the level of goal achievement by the household member in charge of topping-up the gas meter. We used this measure of goal achievement as a proxy for self-control, as discussed in more detail below.

Our results show that stated self-disconnection is positively associated with lower levels of our measure of goal achievement. We also show that a self-determined regular top-up seems to be an effective solution in reducing self-disconnection, however it does not completely offset it. In addition, we show that households which have already experienced self-disconnection are more likely to accept a savings plan. The most popular type of savings plan chosen by the households, in our sample, was a commitment to a regular payment schedule through the year, via mutual agreement with the energy supplier. This suggests that households have a level of insight into their vulnerability to self-disconnection, because this plan is also the plan most likely to minimise the likelihood of self-disconnection.

Our research contributes to the empirical literature on behavioural economics and energy economics. There are a small number of research studies on self-disconnection, see for example Brutscher (2012), Doble (2000), O'Sullivan et al. (2013) and O'Sullivan et al. (2016). These studies do not, however, explore whether goal achievement (and other behavioural characteristics) can explain self-disconnection. Furthermore, our paper suggests novel policy instruments that can help reduce the negative impact of self-disconnection and tests whether households would be willing to accept such saving plans.

The rest of the paper is structured as follows. The next section lays out the background on prepayment metering and the drivers of self-disconnection. It explores, using an illustrative example, how time inconsistency can lead to self-disconnection and presents the different saving plans as potential solutions. Section 3 presents our survey and describes the data. Section 4 describes the methods we use in our empirical analysis and Section 5 presents our results. Section 6 concludes with a summary of findings and a discussion of policy implications.

2. Prepayment meters and self-disconnection

Prepayment meters (PPMs) emerged as a means of offering indebted domestic consumers the ability to pay their energy bills. For the British Gas gas pre-payment customers participating in this survey, they all used physical keys or cards to activate their meters following top-up at a convenient PayPoint or Post Office.[8] This allows the household to decide the amount of energy to be consumed in anticipation of their future consumption. Energy PPMs are very widely used, for example by energy suppliers in Australia, Canada, Mozambique, New Zealand, South Africa, UK and Zambia. Ofgem (2015) estimates for Great Britain suggest that, by 2012, the number of PPM accounts had increased to around 4.2 million household electricity accounts (15.5% of the total) and 3 million household gas accounts (13.3% of the total). The number of PPMs continued to increase in 2014. By 2014 in the UK there were 4.5 million electricity PPM accounts and around 3.4 million gas accounts (Ofgem (2015)).

One important feature of PPMs is that, when the credit is exhausted, the supply of energy can be interrupted and the household 'self-disconnects'. O'Sullivan et al. (2011) have observed that the misleading use of the term self-disconnection is problematic because it erroneously implies that households have agency and are making a voluntary choice to disconnect themselves. This, however, is the common phrasing adopted in the academic literature

[8]More generally, prepayment households insert credit into their meters by the use of, for example, a key or card that is then used or spent when electricity or gas is consumed in the home. Also, as technology improves, other options are becoming available, including top-up codes for online top-up. For more information about the range of pre-payment meters offered by British Gas, see https://www.britishgas.co.uk/products-and-services/gas-and-electricity/tips-and-advice/prepayment-meters-guide.html

(O'Sullivan et al. (2011)). It is also commonly used in policy papers (see for example ConsumerFocus (2010) and Vyas (2014). So we use it here too. This is in contrast to involuntary disconnection imposed by energy suppliers e.g. when supply is disconnected (not temporarily interrupted) because customers have defaulted on bills. Self-disconnection also differs from when households limit their energy use to save cash.[9]

In order to overcome the immediate negative impacts from self-disconnection, especially for vulnerable households in the winter, some suppliers offer an emergency credit. This is a fixed value (usually £5 in the UK) of gas or electricity that is made available, at no extra cost, when a household runs out of credit (Vyas (2014)).[10] Brutscher (2012) analysed the prevalence of self-disconnection using metering data from households with a British Gas electricity prepayment account, over the period 2007-2010. He found that, in 2010, around 78% of households had never self-disconnected; 12% had self-disconnected once; and around 3% of households had self-disconnected more than four times in the year. O'Sullivan et al. (2016), using a postal survey in New Zealand, found that 40% of the respondents had experienced self-disconnection events lasting for at least 12 hours and 17% of the respondents reported that their last self-disconnection event had lasted up to 24 hours. There is a significant variation between these two studies. We note, however, that self-disconnection is more prevalent among gas prepayment customers (the focus of our analysis here) than among electricity prepayment customers. A household is more likely to self-disconnect gas because it is most commonly used for heating, and the demand for heating is relatively elastic in comparison, for example, to the demand for lighting. For vulnerable households this creates significant problems. When financial constraints force households to resort to leveraging their relatively elastic demand for heating in the short-term, then this makes them vulnerable to long-term health consequences that they cannot afford to worry about if their day-to-day priorities revolve around paying bills: lack of heating in winter months is likely to be associated with increased morbidity rates.

[9]This is usually referred in policy papers as self-rationing (for example, see ConsumerFocus (2010)).

[10]Some energy suppliers have also offered a similar feature to the emergency credit, usually named 'friendly credit', which consists of not allowing disconnection in certain periods over the day, whatever the household's usage or credit status. These options give more time for households to top up their card.

2.1. Drivers of self-disconnection

Another characteristic of self-disconnection is that it allows households to opt for discrete jumps in their energy consumption. These discontinuities in energy consumption can be explained by lumpy transaction costs, cognitive constraints (forgetting to top-up and/or forgetting, from one season to the next, the negative impacts from self-disconnection), financial constraints and/or coordination issues (O'Sullivan et al. (2013), Brutscher (2012),ConsumerFocus (2010)). Brutscher (2012) also identified a seasonal pattern to self-disconnection. Unsurprisingly, it is less likely to happen during the spring/summer in colder climates [11] Brutscher argues that time-inconsistency is one possible explanation. Consumers with shifting rates of time preference may experience preference reversals over time, i.e. they change their mind over time. For example, during the winter, a household might plan to save in order to avoid self-disconnection, but when the summer arrives and other more imminent pressures and constraints become more salient then their preferences and choices shift. Households vulnerable to shifting preferences will be more vulnerable to self-disconnection.

To test this hypothesis about the links between self-disconnection, time-inconsistency and preference reversal, Brutscher (2012) incorporated two additional time-inconsistency questions, following a standard format for time preference questions.[12]

The time preference questions were addressed to the individual in charge of topping-up the meter, and to those households who had experienced self-disconnection at least twice over the period 2007-2010. Brutscher (2012) found that households where the individual in charge of purchasing top-ups demonstrated a propensity for preference reversal (as measured by the time-inconsistency questions) were more likely to self-disconnect in the autumn/winter than households in which the person in charge did not suffer

[11] In hot climates, seasons have opposite impacts in terms of increased demand for air-conditioning during hot weather. In countries with extreme fluctuations in weather, these pressures will hit in both winter and summer.

[12] The questions were as follows: 1) 'would you prefer to receive £350 guaranteed today or £400 guaranteed in 1 month?' 2) 'would you prefer to receive £350 guaranteed in 6 months or £400 guaranteed in 7 months?' If the respondents chose £350, the same question would be asked for £450. If respondents still chose £350, they were asked 'how much would we have to offer you to take the higher amount'. It is important to note however, that the evidence is mixed on whether or not these types of hypothetical, self-reported preferences are truly reflective of real preferences.

from preference reversals. These findings suggest that behavioural biases can, at least partially, explain self-disconnection.

2.2. Illustrative example

Below we show an example in order to explain firstly, how time-inconsistency can lead to self-disconnection and secondly, how a savings plan can reduce the likelihood of self-disconnection. This example is an application of the consumer behaviour design used in DellaVigna and Malmendier (2004) and DellaVigna and Malmendier (2004).[13] Their paper focuses on the household preferences and behaviour, but to simplify the analysis we will embed the assumption that firms will not change their decision-making in response.

Consider an energy supplier who offers a energy prepayment plan to a household. There are three periods. In period 0 the household signs the prepayment plan. Period 1 is spring/summer and period 2 is autumn/winter. These periods can be considered on a smaller time scale, e.g. within a given season. The households consume energy in both periods 1 and 2. The prepayment plan incorporates two payments from the household to the energy supplier: p_1 in period 1 and p_2 in period 2. For simplicity, assume no upfront or sign-up fee. The household consumes less energy in period 1 than in period 2 and so their payment is smaller in period 1 than period 2 (i.e. $0 < p_1 < p_2$). Positive consumption generates a positive benefit $b > 0$ and we assume for simplicity that the benefits for the consumer are the same in period 1 and 2. These benefits are deterministic and known. Assume the household needs to save in period 1 in order to pay in period 2 (i.e. if they do not save in period 1, then they will be forced to self-disconnect in period 2). Let the cost of saving in period 1 be $c > 0$, and assume that this cost is known to the household only in period 1, but it is drawn from a known distribution F. Assume that F has a strictly positive density f over $\mathbb{R}$.

In order to incorporate preference reversals we follow the (β, δ) preferences, where $\delta \in [0, 1]$ is a standard discount factor and $\beta \in [0, 1]$ is a discounting parameter, representing time inconsistent preferences, specifically the degree of present bias, consistent with Laibson (1997).[14] A household

[13]DellayVigna and Malmendier use the present biased or (β, δ) preferences, as applied in many papers drawing on seminal insights from Laibson (1997) about time inconsistency and quasi-hyperbolic discounting .

[14]Present bias is the tendency of households to give disproportionate weight to payoffs that are relatively closer in time when considering trade-offs between two future moments;

with (β, δ) preferences has a discount factor $\beta\delta$ between the present and the next period, and a discount factor δ between any two adjacent periods in the future. Let $\hat{\beta}$ be a household's beliefs about its true β. A time consistent household is characterized by $\hat{\beta} = \beta = 1$. A sophisticated household is fully aware of its inconsistency and so, $\beta = \hat{\beta} < 1$. The household is naïve when $\beta < \hat{\beta} = 1$.

In period 0, the household decides whether or not to accept the prepayment plan. The outside option has utility of zero. If the household accepts the prepayment plan, then it assigns discounted net utility $\beta\delta(b-p_1-c+\delta(b-p_2))$ to saving in period 1, and $\beta\delta(b-p_1)$ to not saving in period 1. Thus, in period 0 the household would like to save in period 1 if:

$$\beta\delta(b - p_1 - c + \delta(b - p_2)) \geq \beta\delta(b - p_1) \Leftrightarrow c \leq \delta(b - p_2). \tag{1}$$

In period 1, the household has to decide whether to save or not in order to consume in the next period. The discounted net utility, in period 1, is $b-p_1-c+\beta\delta(b-p_2)$ to saving, and $b-p_1$ to not saving. Hence, the household saves in period 1 if

$$b - p_1 - c + \beta\delta(b - p_2) \geq b - p_1 \Leftrightarrow c \leq \beta\delta(b - p_2). \tag{2}$$

The smaller is β the more likely it is that the household will not save in period 1 and therefore, will be more likely to self-disconnect in period 2.

Saving plans

One possible way of reducing the likelihood of self-disconnection in period 2 is to increase the payment p_1 in period 1, thus enabling the household to save. Suppose the firm increases the payment in period 1 such that the household pays a share of p_2 in period 1, that is $p_1' = p_1 + \Delta$ and $p_2' = p_2 - \Delta$ where $0 < \Delta \leq p_2$. The household will choose to save if $c' \leq \beta\delta(b - p_2')$. For a given $\overline{c}$, the saving condition is more likely to hold because $p_2' < p_2$.

There are two issues related to this change in payments. First, the change in payments may affect the likelihood that the household will accept the prepayment plan in period 0. That is, in period 0, the household will sign-up for the prepayment plan if $\beta\delta(b-p_1'-c'+\delta(b-p_2')) \geq 0$. If δ is close enough

for example, in the short-term, they will favour a payoff in a week to a week-and-a-day; but in the long-term, they will favour a payoff in a year-and-a-day to a payoff in a year, i.e. their time preferences are inconsistent.

to one (i.e. if the household is patient enough), then this change in payments should not affect the sign-up. We note, however, that the households we wish to target lack self-control, leaving them vulnerable to self-disconnection. They do have the spare cash required to save and face higher costs than benefits from self-disconnection. Given these higher costs, if they are strictly rational then they should be prepared to save to avoid self-disconnection. But they lack the self-control to save, and this failure to implement a strategy to avoid self-disconnection reflects inconsistent preferences.

Second, the increase in p_1 will increase the probability of incurring saving costs. Hence, a time-consistent household will be less inclined to accept this change in payment. The same applies to a fully naïve household because it behaves as if were a time-consistent household (i.e. is unaware that they will face negative consequences in the future) given that $\beta < \hat{\beta} = 1$. The sophisticated household is fully aware of its time inconsistency and therefore will be more willing to accept this change in payments given that it will reduce their chances of self-disconnection.

2.3. What could a saving plan look like in practice?

Ideally, a field experiment would be the most robust way to test for the effectiveness of any given energy saving plan. However, field experiments can incur large monetary and logistical costs and it is important firstly to test the basic principles via a preliminary assessment of what types of saving plans are acceptable to consumers. The empirical focus of this paper is to conduct the initial research via a preliminary assessment of real consumers' attitudes towards different potential savings plans. We explore households' stated preferences for different energy saving plans and correlate these preferences with household characteristics. This is an important first step in understanding self-disconnection and possible ways of minimising it. Here, we present some different designs for energy saving plans, including two savings plans to encourage the behaviour changes to ameliorate self-control problems, building on the analyses above.

We use a survey to assess households' preferences for the different customer plans, as follows:

- *Regular payments throughout year:* Based on a summary of the previous year's consumption, the customer agrees to an equal weekly/monthly amount and commits to this payment schedule through the year.

- *Summer fixed extra payments:* The customer commits to additional fixed payments just during summer months. These additional payments could be calculated on the basis of wintertime gas consumption in the previous year, not necessarily equal payments throughout the year. The extra payments would be used to cover higher gas payments in the wintertime.

Going beyond economics, psychologists have analysed extensively goal setting and have reported evidence that goals help to increase performance, including self-set goals (Locke and Latham (2012)). More recently, goal setting has been studied by economists and there is now a growing literature studying the performance of goals showing, theoretically and empirically, that goals, including self-set goals, can have a positive impact on performance and can counteract present-bias.[15]

In order to test whether a household would be more or less willing to accept a self-set goal, we have designed the following two additional saving plans:

- *Voluntary savings target.* The customer chooses a savings target about which they feel comfortable/confident. The customer is responsible for meeting this target and it is up to them whether or not it is achieved in any given month. The credit saved can be used to offset winter consumption. The customer is free to choose how much to save in each week, but is allowed to postpone savings giving them additional flexibility.

- *Ad-hoc extra payments.* The customer makes additional payments as and when they can afford to do so. The customer would not have to nominate a target for savings, but the more they save the more winter consumption will be offset. This is the plan that offers the most flexibility of all commitment contracts, although it is not a real commitment, only an awareness device.

[15]In a theoretical framework, Hsiaw (2013) demonstrates that goals, in the form of targets, that are sufficiently realistic for reference-dependent agents can counteract present-biasedness. Harding and Hsiaw (2014), using a data from a Northern Illinois goal setting program applied to residential electricity consumption, show that households who are aware of their present bias and wish to save electricity choose to save in accordance with their chosen goals (if those goals are realistic).

As noted in the example above, a naïve household is not aware of its time inconsistency and therefore, would be less likely to accept a saving plan that increases its likelihood of incurring a cost associated with saving. Literature suggests that a reminder or feedback may still have positive effects in improving self-control. In particular, Karlan et al. (2016) argue that a reminder can be effective because time inconsistency can be linked to a failure to forecast future expenditure . Reminders can ameliorate this problem to some extent. In behavioural public policy, the "nudging" approach advocated by Thaler and Sunstein (2008) does focus on re-designing "choice architecture" to encourage choice-making that is more beneficial to the individual, and an important facet of a well-designed choice architecture, according to Thaler and Sunstein, is to provide frequent and salient feedback. A energy consumption feedback mechanism would be consistent with these policy insights.[16]

In order to assess household preferences for reminders or feedback mechanisms, we have designed the following feedback in the prepayment meter context.

- *Feedback on consumption.* Without changing the payment plan, the household receives regular feedback in the summer about the average gas payments. For example: 'Last year you spent £20 on gas between July and September and you spent £120 on gas between October and December'.

3. Data

3.1. Sample summary statistics and stated self-disconnection

The data source was responses to a survey developed and conducted in collaboration with British Gas, specifically targeted at British Gas gas prepayment customers. The survey was implemented online between January and February 2013 and was sent via email to 20,000 customers, with 11%

[16]In the energy domain, Asensio and Delmas (2016), using a randomized controlled trial with residential electricity households, show that message framing can have a positive impact on conservation behavior. Another example is from Allcott and Rogers (2014) demonstrating that energy reports, with a social comparison element, can have a potential impact on energy conservation. In the savings domain, Karlan et al. (2016) show that reminder messages increase the likelihood that individuals achieve their saving goals. Relating to gym attendance, Calzolari and Nardotto (2017) show that weekly reminders can induce users of a gym to increase their gym attendance over an extensive period.

of surveys not delivered because of incorrect or out-of-date contact details. The customers contacted were those identified as being most likely to be responsible for paying the gas bills within the household. Participation in the survey was voluntary and no monetary incentives were involved. In total, we obtained 1539 responses, however for certain questions we had a lower number of observations to use in econometric estimations.[17]

The use of an online survey is a likely contributor for the low response rate because response rates for online surveys are usually lower than the response rates for other field research methods such as face-to-face interviews (Couper (2000),Couper (2017)). The research team was not able to contact respondents directly because we were not permitted to see the contact details of British Gas customers. So British Gas was required to send the emails to meet their obligations to secure client privacy under the UK's Data Protection Act 1998. The fact that the emails were sent by British Gas could have had an impact on the response rate if discontented customers were less inclined than others to answer the survey. Also, some customers may have classified British Gas emails as spam, decreasing the number of emails actually received and read by potential respondents. To minimise these negative impacts on potential response rates, potential respondents were informed that the research was a collaboration between British Gas and University of Cambridge and that their responses would be confidential to the research team, and no individual details revealed to British Gas. Contact details for the researchers were provided, in case respondents had questions and concerns. We expected a relatively low response rate, as is generally true for online surveys (Couper (2000), Couper (2017)) and so we aimed to send the survey to a much larger number of potential respondents than we needed to secure a suitable sample size.

The survey included a series of detailed questions about the respondents' demographics (i.e., age, gender, education, number of adults in the household and income), alongside questions to assess self-disconnection history, behavioural characteristics and energy saving plan choices. For a summary of the main variables employed in the paper see Table A1 in the appendix.

Table 1 compares the age and gender of the respondents of the survey with the group of customers who have a contract with British Gas for the supply

[17]This was especially the case for the questions about income and number of children in the household.

of gas through a prepayment meter. While there are no significant differences (at 5% level) in relation to gender, there are differences in relation to age intervals. In particular, the number of young people answering our survey was not representative relative to the population of customers on British Gas contracts. Specifically, fewer young people responded and, therefore, our survey results are skewed towards older people. So one caveat on our analysis is that it is more likely to be representative of older consumers. However, within this group, elderly consumers are an important group of the vulnerable fuel poor, with higher winter-time mortality rates than other age groups and so policy solutions are needed to enable this group specifically to plan their energy consumption and savings more effectively.[18]

Table 1. Survey sample: control variables

	Category	**Survey sample (%)**	**PPM Gas in BG (%)**
Gender	Male	37.8	40
	Female	62.2	60
Age	21 and Under	0.2	2.2
	22 to 34	5.7	25.9
	35 to 44	20.7	24.4
	45 to 54	38.6	24.7
	55 to 64	25.1	13.8
	65 and Over	9.7	9.1

[18]We were not able to correlate the responses with a broader range of characteristics, for example income and socio-economic status, because British Gas does not automatically collect these data and we were constrained by British Gas to work with the household characteristics already included in British Gas' surveys.

Table 2.
Summary statistics of explanatory variables

		Whole sample			Stated SD	Stated EC
	Obs	Mean	95% Conf.	Interval	Mean	Mean
Age						
21 and Under	1539	0.00	0.00	0.00	0.00	0.00
22 to 34	1539	0.06	0.04	0.07	0.07	0.06
35 to 44	1539	0.21	0.19	0.23	0.21	0.22
45 to 54	1539	0.39	0.36	0.41	0.43	0.41
55 to 64	1539	0.25	0.23	0.27	0.23	0.23
65 and Over	1539	0.10	0.08	0.11	0.06	0.06
Female (=1)	1539	0.62	0.60	0.65	0.66	0.64
Household adults	1521	2.19	2.13	2.24	2.26	2.26
Income levels						
Low income	1232	0.41	0.39	0.44	0.41	0.38
Medium income	1232	0.42	0.39	0.44	0.44	0.45
High income	1232	0.17	0.15	0.19	0.16	0.17
Education levels						
None	1387	0.13	0.12	0.15	0.11	0.12
Basic	1387	0.34	0.32	0.37	0.35	0.34
Medium	1387	0.38	0.35	0.40	0.40	0.40
Higher	1387	0.14	0.13	0.16	0.14	0.14
Behavioural characteristics						
Saving behavior (=1)	1183	0.24	0.22	0.27	0.27	0.21
Top-up all year (=1)	1505	0.10	0.09	0.12	0.07	0.07
Inconvenient (=1)	1480	0.33	0.31	0.36	0.43	0.36
Low goal achievement (=1)	1163	0.09	0.07	0.10	0.10	0.09
Medium goal achievement (=1)	1163	0.30	0.27	0.32	0.37	0.32
High goal achievement (=1)	1163	0.60	0.57	0.63	0.52	0.57

NB: SD = self-disconnection; EC = emergency credit. See Table A1 for full definitions.

Summary statistics for our sample of households are provided in Table 2. Column 1 reports mean values for the whole sample. The respondents in the sample are, on average, between 45 and 54 years old, with basic and medium levels of education and lower and medium levels of household income. The household is composed, on average, of two adults.

Information about household income and education is captured by a group of dichotomous variables, where the reference variables for each group are low income, and no education or basic education.

Table 2 also provides summary statistics for our measures of self-disconnection and emergency credit. These are self-reported measures based on specific survey questions. The respondents were asked two short statements, and their responses were captured on a Likert scale.[19] We asked the following questions:

To what extent do you agree with the following statements?

1. I rarely use the emergency credit.
2. Sometimes the emergency credit runs out.

The first question we label as 'emergency credit', the second as 'self-disconnection'. To clarify the difference, the two questions are addressing different aspects of emergency credit and self-disconnection. As explained above, self-disconnection and emergency credit are closely related because emergency credit is a form of 'grace' period, before actual self-disconnection takes hold. The first question captures households who are perhaps 'dabbling' with emergency credit. They may seem vulnerable to self-disconnection but may not ever self-disconnect (e.g. if they are just procrastinating about topping-up). In fact, these households may, in some senses, be rational if leaving it to the very last minute to top-up allows them to economize on the transactions costs associated with an inconvenient topping-up process. The second question captures those households who actually face the harsh reality of self-disconnection - their emergency credit runs out and they are left without gas. This is likely to be about more than procrastination and may link to other behavioural constraints and/or other non-behavioural constraints, such as poverty, which are preventing households from topping-up. The households who are experienc-

[19] A standard 5-point Likert scale was used, incorporating the following responses: strongly agree; agree; neither agree nor disagree; disagree; and strongly disagree.

ing problems with emergency credit running out are likely to be those who would benefit most from an effective energy savings plan.

We constructed binary variables to capture more distinctly the patterns in use of emergency credit and experience of self-disconnection. To capture those respondents who *do* use emergency credit in general we labelled the first question *stated emergency credit* and we assigned value of one if the respondent answering that they 'strongly disagree' or 'disagree' with the statement that they rarely use emergency credit, and zero otherwise. To contrast with the groups who have actually self-disconnected, we labelled the second statement *stated self-disconnection* and assigned value of one if the respondent answered 'strongly agree' or 'agree' to the 'Sometimes emergency credit runs out' and a value of zero otherwise. In our sample, at least 62% of the respondents stated that they had already used the emergency credit facility and around 39% had already self-disconnected at some point.

In section 5, we have also considered other definitions of these two variables as robustness tests. For instance, we conducted ordered probit estimations using the full range of the Likert scale responses to check the robustness of our binary classifications derived from these responses. We also conducted additional estimations to show that how the 'neither agree nor disagree' responses were included in the binary dependent variables did not significantly affect the econometric results.

3.2. Survey data on behavioural characteristics

For the conditioning variables, we constructed a measure to assess the level of goal achievement of the individuals and used this as a proxy for self-control. Psychologists have considered the impact of conscientiousness on self-control and goal achievement links to the conscientiousness trait, as explored in the economic psychology literature on the Big Five personality traits (e.g. see McC (a), McC (b), Costa and McCrae (1992), Costa and McCrae (2005), Costa and Widiger (1994), Borghans et al. (2008), Baddeley (2019). In particular, psychology literature has pointed to conscientiousness as an important predictor of academic performance, mostly associated with sustained effort and goal setting, e.g. see Conard (2006).

We focussed on goals broadly defined, because this links with goal achievement, as the most relevant facet of conscientiousness in explaining self-control in the context of self-disconnection. Due to the limited number of questions in the survey, we designed a single question that we further use to construct a measure of goal achievement. This question provides broad information

about goal task, planning and procrastination issues, as opposed to a more in-depth analysis of goal achievement.

Which of the following statements best describe you? (Choose two responses at most)

(a) I usually achieve my goals.
(b) I usually set-up weekly or monthly goals that I wish to achieve.
(c) I usually avoid or delay a task that requires a lot of thinking.
(d) I have difficulties in completing a task that requires organization.
(e) I don't usually achieve my goals.

Aside from a) and e), these options are not mutually exclusive and so we did not ask the respondents to choose just one. To categorise the different possible combinations of responses, we delineated three different levels of goal achievement: *high goal achievement*, *medium goal achievement*, and *low goal achievement*. Individuals who usually achieve their goals would select the statements a) or a) with b). Those with a medium level of goal achievement would select b), c) and/or d) but not a) or e). Those with a low level of goal achievement would select e) alone or in combination with b), c) or d). Overall, the majority of the respondents (60%) are considered as *high goal achievement* types against 9% of the sample categorised as *low goal achievement* and 30% as *medium goal achievement*. This index has some limitations in the sense that it is composed from self-reported variables and therefore, it is most likely subject to self-reported bias, but it does correlate to some extent with a number of observable measures.[20]

In addition to goal achievement, we also measured other behavioural characteristics that can help explaining self-disconnection. As noted above, a possible explanation for a household using the emergency credit or self-disconnecting is that it is inconvenient to top-up, for example due to transaction costs. That is, every time households need to top-up, they have to go to an outlet, or if the payment can be made through an online account, households still need to have access to internet.[21] In order to take into account this factor we have asked the respondents to answer, on a scale from 'strongly disagree' to 'strongly agree', the statement *'Pay As You Go makes*

[20]Table A2 shows how our measure of goal achievement correlates with observable variables.

[21]Other reasons may include liquidity constraints or lack of income.

it easy to pay for my gas'. From this we constructed the binary variable *inconvenient* equal to zero if the household had answered 'strongly agree' or 'agree' to the question, and equal to one otherwise.[22]

The respondents were also asked to state whether they top up more over the winter or roughly the same over the year. This is summarised in the variable *top-up all year* - equal to one if household i tops up roughly the same all year around and zero if household i tops up much more over the winter. The majority of the respondents choose to top-up according to their needs, and so their top-ups were more frequent over the winter. From those households who top up roughly the same all year round, only 29% had self-disconnected; whereas 41% of those who top up more during the winter had already self-disconnected. This is a particularly interesting finding as it shows that those households who do not have a self-imposed regular payment schedule through the year, are more vulnerable to self-disconnection.

In addition, even though British Gas does not have a facility for energy savings (one of the reasons why we were testing households' likely uptake of a resolution to this problem) we were interested to know whether households are more or less likely to save spare cash. So we included a question asking, on a scale from 'strongly disagree' to 'strongly agree', *'When I'm using less gas in warmer months I like to add any spare cash to my savings'*. This was redefined into the variable *saving behaviour*: equal to one if the household strongly agreed, agreed or neutral, and zero otherwise.

3.3. Survey data on saving plans

Regarding the questions on the preferences about the saving plan, we did not ask open-ended questions. Instead, we gave a specific text for each of the saving plans, similar to the saving plans' description in section 2.3 and asked the respondents which of the plans they would prefer.[23]

These questions capture stated preferences rather than revealed preferences. Stated preference questions tend to suffer a number of limitations e.g. see Louviere et al. (2000). Stated preference questions involve hypothetical scenarios, which can lead to two problems: (1) respondents may find some trade-offs difficult to evaluate because they are unfamiliar with options

[22]In all re-defined variables throughout the analysis, the 'don't know' option was dropped.

[23]See Appendix for the questions related to the saving plan choice or the online appendix for the full questionnaire.

on offer, in this case the suggested saving plans; and (2) as the number of attributes increases, the complexity and the number of combinations for comparison increases, which may lead to decreased engagement in the survey from the respondents, limiting the reliability of the responses.

Revealed preference analysis was not feasible for this analysis because it was not possible for British Gas to offer its customers energy savings plans as part of this study. Nonetheless, stated preference questions are still informative, and can be used to obtain hypothetical data and estimate the likely attractiveness of the saving plans. This information is useful in understanding people's preferences over choices not yet available, for example in the design of new technologies for which revealed preference data are not yet available. For these reasons we took great care in explaining the different plans in detail and focussed on differences in the attributes across the plans.

We included in the survey one extra alternative ('none of the options') and we used this as our reference choice, to allow that some respondents do not want any energy savings plan at all. No savings plan is also the current status quo option for all customers given that it is the only payment option currently available to respondents. So it is, in practice, their reference point.

Table 3 shows the distribution of the energy savings plan choices available to the households in the sample. Interestingly, when asked to choose between the different saving plans or none of the options, around 36% of the households chose the regular payments throughout the year, followed by almost 15% choosing the feedback option. Respondents were least interested in voluntary savings and the summer fixed payments. It is interesting that the most popular options were the least flexible (regular payments) and most flexible (no savings plans at all) suggesting that there are significant individual differences across the respondents across the spectrum of savings plans suggested. In the econometric analysis, we will explore how these different savings preferences link to individual differences and specifically to behavioural factors associated with time inconsistency and goal achievement.

Table 3. Distribution of the saving plans

Saving plan	Freq.	Percent	Cum.
Regular payments	458	36.46	36.46
Voluntary savings	106	8.44	44.9
Ad-hoc payments	131	10.43	55.33
Summer fixed payments	47	3.74	59.08
Feedback on consumption	187	14.89	73.96
None of the above	327	26.04	100
Total	1,254	100	

Both low-income households and those stating that they had self-disconnected deserve special attention, especially those answering that they were not interested in any savings plans. Table 4 shows the choices made by these two sub-groups of households. For both these sub-groups, households prefer a regular payment throughout the year, as for the rest of the sample. There are, however, some interesting links within this sub-group. Around 90 households who had stated they self-disconnected preferred not to have a saving plan. One reason for this might be that these households are unaware of their limited self-control. In fact, 41 respondents out of the 90 who were not attracted by a savings plan, had stated they self-disconnected even though they thought they had high levels of goal achievement. This can be argued as a sign of naiveté, consistent with the categorisations in O'Donoghue and Rabin (1999, 2001), as outlined above. Feedback about energy consumption patterns might help increase the salience for individuals of their potential self-control constraints, and/or it might increase the salience of information about the extent of energy consumption increases in the winter-time for these households. Another explanation could be that households are facing binding liquidity/financial constraints and so have no access to the spare cash that might enable them to save.[24]

Failing to understand the savings plans offered is another potential explanation for the inconsistency in these respondents' belief in their own goal achievement versus their self-disconnection experience. Of the 90 respondents not attracted by any savings plan, 33 had a history of self-disconnection and reported lower levels of educational attainment. So another possibility is

[24]Ideally, we would have liked to ask more questions about wealth so that we could have tested this hypothesis empirically, but questions about financial position were precluded as potential violations of British Gas customers' privacy.

that the energy savings plans offered were difficult to understand. This underscores the importance of avoiding esoteric and excessively formal language in communicating different options for energy savings.[25]

Table 4. Saving plan choices by sub-groups of households

Saving plan	Low income	Stated self-disconnection
Regular payments	142	179
Voluntary savings	44	41
Ad-hoc payments	51	48
Summer fixed payments	14	20
Feedback on consumption	53	74
None of the above	116	90
Total	420	452

Notes: Pearson $chi2(5) = 15.739$ ($p = .008$) for the cross-tabulation between saving plan and low income. Pearson $chi2(5) = 15.252$ ($p = .008$) for the cross-tabulation between saving plan and stated self-disconnection.

In summary, most households appear to be interested in some sort of energy savings plan and in general, they agree that it would be a good way to spread the cost of seasonal changes in gas use.[26] We find that those households stating they have already self-disconnected would like to commit to a saving plan. When asked specifically about their preferred saving plan, a significant percentage of the households chose the regular payments saving plan as their preferred plan, although many respondents expressed concerns about the lack of flexibility implicit in this sort of plan. Alongside concerns about loss of flexibility, respondents were also worried about lack of spare cash, potential increases in gas prices, forgone savings interest from energy savings during the summer, the likelihood they might forget to save, and also their mistrust of the firm.

[25]This problem affects all consumers across a range of consumer choice problems and there is evidence that people choose many options, including in the context of online shopping, without properly understanding the terms and conditions attached to the options.

[26]Households were asked to answer in a scale from 'strongly disagree' to 'strongly agree" the following statements about their preferred saving plan: 'It would be a good way to spread the cost of seasonal changes in gas use.'; 'It would help me focus on budgeting to cover my gas needs.'; 'It sounds too complicated.'; 'I'd worry about losing the credit I had saved.'; and 'It could help me reduce my spending on non-essential purchases'.

4. Estimation Strategy

To unravel some of the associations between propensity to use emergency credit and vulnerability to self-disconnection, in this section we estimate a range of econometric models to capture these phenomena as a function of behavioural characteristics and other conditioning variables. Given potential endogeneity of the behavioural characteristics, we use a range of estimation methods, as explained below. In addition, we estimate a model designed to capture the types of households which might be willing to accept an energy savings plan.

4.1. Stated self-disconnection

Given that emergency credit and self-disconnection are linked for many consumers, we modelled stated emergency credit, ec_i and stated self-disconnection, sd_i together in a seemingly unrelated regression (SUR) system. SUR allows the different dependent variables to be generated by processes that are independent except for the correlated errors. Let us assume that stated emergency credit for household i is identified by the latent variable ec_i^* and that sd_i^* is the latent variable measuring stated self-disconnection for household i. The first model becomes:

$$ec_i^* = \gamma_1 x_{1i} + \gamma_2 x_{2i} + \mu_{1i}, \tag{3}$$

We observe ec_i:

$$ec_i = \begin{cases} 1 & \text{if } ec_i^* > 0 \\ 0 & \text{otherwise.} \end{cases}$$

The second model becomes:

$$sd_i^* = \alpha_1 x_{1i} + \alpha_2 x_{2i} + \alpha_3 x_{3i} + \mu_{2i}, \tag{4}$$

We observe sd_i:

$$sd_i = \begin{cases} 1 & \text{if } sd_i^* > 0 \\ 0 & \text{otherwise.} \end{cases}$$

where x_{1i} is a vector of demographic characteristics, x_{2i} is a vector of behavioural characteristics (with the exception of our measures of goal achievement) and x_{3i} is a vector of our goal achievement variables. We use *high goal achievement* as a reference category in our estimations. The error structure can be described as follows:

$$(\mu)_{1i}\,\mu_{2i} \sim N\{(0)\,0, (1)\,\rho\rho 1\}$$

where ρ captures the correlation in the error terms between *self-disconnection* and *emergency credit*.

4.2. Preferred saving plan

In the second step of our analysis we show a theoretical framework for households choosing a saving plan. To re-cap on the options offered, a household i is faced with a choice between the following alternatives or plans: (1) regular payments throughout year, (2) voluntary savings target, (3) ad-hoc extra payments, (4) summer fixed extra payments, (5) feedback on consumption, (6) none of the options.

Following the additive random utility model for multiple alternatives (see Cameron and Trivedi 2005), the household utility associated with the j^{th} choice can be represented as

$$U_{ij} = x_i^{'}\beta_j + \epsilon_{ij}, j = 1, ..., 6 \tag{5}$$

where U_{ij} represents the utility of household i of saving plan j. ϵ_{ij} is the random component of utility that stands for the households' unobserved characteristics. β_j is a vector of alternative-specific parameters.

Each household decision is based on choosing the plan that offers the highest utility level. A certain household i chooses saving plan j if the utility derived from it is higher than the utility that he had derived from choosing 'none of the options' and from all other saving plans, $U_{ij} \geq U_{is}$, for all $j \neq s$. The choice s, 'none of the options', is used as the reference choice. Then, the probability for household i to choose saving plan j is given by:

$$\Pr\left(\mathrm{PP}_i = j\right) = \Pr\left(U_{ij} \geq U_{is}, \forall j \neq s\right) = \Pr\left(x_i^{'}\beta_j + \epsilon_{ij} \geq x_i^{'}\beta_s + \epsilon_{is}, \forall j \neq s\right) \tag{6}$$

$$= \Pr\left(x_i^{'}\beta_j - x_i^{'}\beta_s \geq \epsilon_{is} - \epsilon_{ij}, \forall j \neq s\right) \tag{7}$$

We assume that the errors ϵ_{ij} are i.i.d. type-one extreme value, with density

$$f(\epsilon_{ij}) = \mathrm{e}^{-\epsilon_{ij}} \exp(-\mathrm{e}^{-\epsilon_{ij}}), j = 1, ..., 6.$$

This results in the multinomial logit $\Pr\left(\mathrm{SP}_i = j\right) = \frac{\mathrm{e}^{x_i^{'}\beta_j}}{\sum_{s=1}^{6} \mathrm{e}^{x_i^{'}\beta_s}}$. The model then takes the following form:

$$\Pr\left(\mathrm{SP}_i = j\right) = F(\beta_{0j} + \beta_{1j}x_{1i} + \beta_{2j}x_{2i} + \beta_{3j}x_{3i} + \beta_{4j}ec_i + \beta_{5j}sd_i + \epsilon_{ij}) \tag{8}$$

where SP_i represents household i's decision about saving plan j. Controls x_{1i}, x_{2i} and x_{3i} are as before. This is estimated using a multinomial logit (MNL). By estimating equation (5) using a MNL model, we examine the direct impact of demographic and behavioural characteristics on the probability of choosing between one of the saving contracts against the reference category of not choosing any of the listed options.

The MNL has some obvious problems. One assumption underlying MNL which undermines its efficiency is the assumption of independence of irrelevant alternatives (IIA). This property states that the ratio of the probabilities of choosing one alternative over another, if both alternatives have a non-zero probability of choice, is not affected by the presence or absence of any additional alternatives in the choice set Louviere et al. (2000). This assumption is quite strong and it may not hold, for example when two or more alternatives are closer substitutes than the other alternatives.

To address this potential problem, we use the Hausman test as the standard procedure to test whether the IIA property in the MNL is violated. Further, this property implies that the random term in the utility function is independent across alternatives and identically distributed. This is related to another problem of the traditional multinomial logit which is the assumption of homogeneous tastes for observed attributes. A further relevant source of heterogeneity, not considered in the MNL, is scale heterogeneity which refers to heterogeneity in variance associated with the random term in the utility function. This potential limitation is not so relevant in our case as we have only one choice situation and, therefore, it would be hard to identify the parameters that characterize heterogeneity in choice behavior of the saving plans.

5. Results

5.1. Emergency credit and self-disconnection

As explained in section 4, estimation results for *emergency credit* and *self-disconnection* are obtained by estimating equations (1) and (2) through a seemingly unrelated bivariate probit model. Table 5 reports the average marginal effects and conditional probabilities. The two equations are statistically significantly correlated ($\rho = 0.278$). This result implies that the error terms of both equations are correlated and we gain a more efficient estimator by estimating the two equations jointly compared to estimating them separately. *Inconvenience of top-up* increases the predicted probability of

self-disconnection by around 16%; whereas *top up all year* decreases the predicted probability of using the emergency credit and of *self-disconnection* by around 14%.[27] A self-setting regular top up seems to be effective in reducing self-disconnection, although it does not completely offset it. *Saving behaviour* (i.e. being more prone to save) affects significantly and negatively the use of emergency credit but is not significantly associated with self-disconnection. Hence, self-imposing a commitment mechanism such as saving during warmer months is not sufficient in minimising self-disconnection. In addition, education does not seem to affect the use of emergency credit or the tendency to self-disconnect. We also find a significant relationship between *goal achievement* and *self-disconnection*. Note that we have used, as a reference category, the high level of goal achievement. Thus, moving from the high category to the medium category increases the predicted probability of *self-disconnection* by 9.6%. This emphasizes our next result, that *goal achievement*, to some extent, plays a role in *self-disconnection*. We control for *goal achievement* only in equation (2) since the use of emergency credit is not necessarily related to self-control issues, as noted above. A household may use the emergency credit because they simply forgot to top up, or it may even be the case that the emergency credit is being used as a short small interest free 'loan', and hence its use is rational. The last column of Table 5 reports the conditional predicted probability of *self-disconnection* given that *emergency credit* has been used. These effects are similar to the average marginal effects of *self-disconnection*, including the statistical significance of the variables. The reverse conditional probability does not apply in our case, because self-disconnection mostly happens once emergency credit runs out.

[27]Notice that these are categorical variables and so the marginal effects show how the probability of stated self-disconnection and stated emergency credit change as the categorical variable, e.g. inconvenience of top-up, changes from 0 to 1.

Table 5. Seemingly unrelated bivariate probit: stated EC and SD

	Average marginal effects		Conditional Probability
	EC	SD	$\Pr(sd = 1 \mid ec = 1)$
Demographics			
65 and over	-0.172*	-0.201**	-0.184**
	(0.090)	(0.091)	(0.095)
Female	-0.010	0.019	0.022
	(0.035)	(0.035)	(0.036)
No. of adults in household	0.040***	0.026*	0.021
	(0.016)	(0.015)	(0.016)
Education			
Medium	0.047	0.019	0.013
	(0.035)	(0.035)	(0.037)
High	0.022	-0.009	-0.014
	(0.048)	(0.048)	(0.049)
Behavioural characteristics			
Saving behavior	-0.081**	0.016	0.030
	(0.032)	(0.032)	(0.034)
Top up all year	-0.152***	-0.143**	-0.126**
	(0.054)	(0.059)	(0.062)
Inconvenient	0.009	0.158***	0.165*
	(0.035)	(0.033)	(0.034)
Low goal achievement		0.110**	0.116**
		(0.056)	(0.059)
Medium goal achievement		0.096***	0.102*
		(0.035)	(0.036)
ρ	0.278	LL	-1152.4
Wald $\chi^2(24)$	82.13	Prob> χ^2	0.000
Obs.	905		

Notes: Average marginal effects reported. Standard errors (Delta method) in parentheses. Significance levels ***, **, * indicate 1%, 5%, and 10% respectively. LL= log likelihood. Reference categories: Age to 34; low education; low income; high goal achievement. Ages 65 and over omitted. SD =self-disconnection; EC =emergency credit. See Table A1 for full definitions.

Robustness Check. The model above relies on the definitions of the dependent variables. To test the robustness of our definitions, and specifically to ensure that our estimations are not distorted by how we included the 'neither agree nor disagree' responses, we tested the same model, seemingly unrelated bivariate probit, using an alternative definition of the dependent variables, *self-disconnection* and *emergency credit*, dropping the 'neither

agree nor disagree' category. Table A3 reports the results. No sign and/or statistically significant changes happened in the parameters for the *emergency credit* estimations. Similarly for the *self-disconnection* model, the sign and significance of the main explanatory variables did not change. The similarity between the models with the two different definitions suggests that the treatment of 'neither agree nor disagree' in the construction of the variables did not make a significant difference.

We also tested a seemingly unrelated bivariate ordered probit model. This estimation method also allows for correlation between the latent variables underlying the two dependent variables, i.e. self-disconnection and emergency credit, even after controlling for observables. However, the latent variables are ordered in a scale from strongly disagree to strongly agree. Table A3 shows that the results remain significantly similar to the coefficients obtained through the seemingly unrelated bivariate probit model.

5.2. Preferred Saving Plan

Though a significant percentage (around 36%) of households have chosen regular payments saving plan as their preferred option, as shown in Table 6, a number of respondents expressed concerns about the lack of flexibility implicit in such an option. In order better to understand these concerns, we investigated more deeply which type of household has chosen each plan.

Table 6 shows the estimation results for the choice of the preferred saving plan. All the saving plans are compared to the alternative choice 'none of the options' - which captures those respondents who are not interested in any savings plan at all. Keeping all other variables at their means, the predicted probability of choosing a regular payment plan instead of keeping with the current plan is 18.7% higher for those who find pre-payment meters to be an inconvenient way to pay. In addition, the predicted probability of choosing a voluntary savings plan as opposed to keeping the current plan is 5.4% higher for those who *top-up all year* around and 3% for those who has a *saving behavior*. We further note that although our goal achievement measures are relevant determinants of self-disconnection, these are not statistically significant in the multinomial choice of the saving plans analysed here.

Table 6. Multinomial logit: preferred saving plan

	Regular payments	Voluntary savings	Ad-hoc payments	Summer fixed payments	Feedback on consumption
Demographics					
65 and over	-0.186**	-0.075	0.003	0.039**	0.113**
	(0.073)	(0.049)	(0.043)	(0.018)	(0.047)
Female	-0.016	0.018	0.032	0.004	-0.001
	(0.037)	(0.021)	(0.024)	(0.011)	(0.027)
No. of adults in household	0.029	-0.003	-0.012	-0.003	-0.009
	(0.016)	(0.009)	(0.011)	(0.005)	(0.012)
Education					
Medium	-0.063*	0.005	-0.034	0.002	0.025
	(0.037)	(0.020)	(0.023)	(0.010)	(0.028)
High	-0.073	-0.020	-0.026	-0.001	0.092***
	(0.051)	(0.030)	(0.032)	(0.016)	(0.034)
Stated emergency credit	-0.056	-0.013	0.021	0.030**	0.034
	(0.036)	(0.019)	(0.023)	(0.012)	(0.027)
Stated self-disconnection	0.010	0.019	-0.010	0.015	0.037
	(0.036)	(0.019)	(0.022)	(0.010)	(0.026)
Behavioural characteristics					
Saving behavior	0.003	0.031*	-0.042*	0.018*	0.023
	(0.034)	(0.019)	(0.021)	(0.010)	(0.025)
Top up all year	0.021	0.054**	0.000	-0.024	-0.023
	(0.061)	(0.028)	(0.037)	(0.027)	(0.048)
Inconvenient	0.187***	0.002	-0.028	0.002	-0.014
	(0.037)	(0.021)	(0.025)	(0.010)	(0.028)
Low goal achievement	-0.105	-0.040	0.031	0.022	0.038
	(0.065)	(0.042)	(0.034)	(0.015)	(0.045)
Medium goal achievement	0.025	0.015	-0.020	0.000	0.017
	(0.038)	(0.020)	(0.025)	(0.011)	(0.028)
Pseudo R^2	0.046	LL	-1359.48	Prob $> \chi^2$	0.000
Obs.	905				

Notes: Base comparison: 'None of the options'. See also Table 5 notes.

The Hausman test of IIA assumption were computed and we cannot reject the null hypothesis of non-violation of IIA. Nevertheless, there is still a possibility that there is scale and taste heterogeneity in the data that we are not taking into consideration through a MNL model.

In summary, although our multinomial logit model did not show that goal achievement was a significant predictor of respondents' choices across the different types of saving plans, nonetheless we do find that goal achievement has a role in predicting self-disconnection. We show that an inter-

nal commitment/self-commitment device is not sufficient in eliminating self-disconnections. We find that a household who has already experienced self-disconnection has a greater probability of accepting a saving plan.

6. Conclusion

This paper presented empirical evidence on the role of behavioural characteristics in explaining self-disconnection. We designed and implemented a survey specifically for prepayment gas households in the UK. Our results showed that, in our sample, stated self-disconnection is positively associated with lower levels of goal achievement. A self-setting regular top up could be effective in reducing self-disconnection, however it would not completely offset it. In addition, we designed different saving plans that can contribute to a decrease in the likelihood of self-disconnection. We examined whether a household would be willing to accept different forms of saving plan. We found that a household who has already experienced self-disconnection has a greater probability of accepting a saving plan. The most attractive type of saving plan chosen by the households in our sample was regular payments throughout the year, involving a commitment agreed with the firm to follow a set payment schedule. This is particularly relevant given that this is the saving plan that is most likely to minimise the likelihood of self-disconnection. These findings help to address some important policy questions around enabling poorer households more effectively to plan their energy consumption. If they are less able to accumulate savings during the summer months, either because they do not have convenient ways to save and/or because they are prone to time inconsistency or low levels of goal achievement, then offering them energy savings plans may help them to manage their energy bills more effectively throughout the year. This analysis suffers from some limitations, including the fact that the response rate was low, though this is common with online surveys.

In terms of limitations and directions for future research, these could focus on expanding the sampling frame to address some of the limitations associated with this form of survey. The response rate was low, though this is not uncommon with online surveys. The focus on British Gas consumers may have created some sampling biases if specific groups were more likely to be non-respondents than others. Specifically, we had a relatively low number of responses from young people under 22 years of age. Whilst this is representative of most ordinary households, for young people in mul-

tiple occupancy housing, there will be an additional range of drivers and constraints. These could be explored in more extensive surveys, including stratified surveys targetted at the general population and towards capturing representative sub-samples. Also, the consumers surveyed were using a limited range of pre-payment meters and future research could be designed to explore what is possible with new generation pre-payment meters.The framing of the questions in terms of the language used may have affected responses and future research could embed experimental designs designed to capture how different framing affects respondents' stated preferences. This aspect could also be captured by complementing this standard survey analysis with surveys designed within the context of a discrete choice modelling methodology, following methodologies outlined by Train (1998, 2003); Train and Weeks. Smart meter technologies could, for example, be designed to incorporate energy savings tools, thus providing another route for improving energy efficiency and convenience for a wide range of users, especially for those vulnerable to fuel poverty. If these new capabilities are to be effectively realised, designers need a strong grounding in real evidence about real energy users answering some crucial questions. What characterises prepayment customers' behaviour? What do they want/need? What do they choose? From a behavioural economics perspective, these desires/needs and choices might diverge and policy can play a key role in bringing desires, needs and choices closer together. Our evidence demonstrates the importance of understanding that different people will want/need different capabilities with their smart and pre-payment meters. They will be driven by different goals and behavioural characteristics and will face different economic, financial and behavioural constraints.

The link to energy poverty emphasizes the importance of the present study in providing specific, simple solutions to increase levels of energy comfort and efficiency. The savings solutions suggested in this paper have the potential to increase welfare by more effectively matching preferences with choices. They would not necessarily require any additional costs for the government if energy utilities can be shown that reduced likelihood of self-disconnection will be in their commercial interests, as well as in the interests of their customers. Smart meter technologies could enable tailoring of energy plans to take account of some of the differences in individuals' preferences which we have identified. So, if well-designed and properly implemented, smart meters have the potential to be unequivocally beneficial in increasing social welfare. Nonetheless, our results suggest that further research is war-

ranted to test the effectiveness of the proposed energy savings plans, including which features of the saving plans generate minimum self-disconnections in practice. Another potential limitation would be if energy savings plans just crowd-out other forms of savings, and so have neutral impact on total household savings. This paper provides a first step in answering these important economic and policy issues from a behavioural economics perspective, and hopefully will precipitate further research exploring these questions and potential solutions more fully.

Table A1. List of main variables

Age of respondent	Categorical ordered variable.
Female	Gender dummy, Female=1 and Male=0.
Household adults	No. persons with more than 16 years old in the household.
Income	Household monthly income, including any benefits.
Low	=1 if household monthly income $\leq$ £1000, $otherwise = 0$
Medium	=1 if household monthly income between £1001 & £2000, otherwise=0
High	=1 if household monthly income is over £2000, otherwise=0
Education	Education level of the respondent.
None	=1 if highest education lower than basic, otherwise =0
Basic (O-levels)	=1 if highest education is basic , otherwise =0
Medium (A-levels, vocational)	=1 if highest education is medium, otherwise =0
High (University degree)	=1 if highest education is higher education, otherwise =0
Stated emergency credit	I rarely use the emergency credit.
To what extent do you agree	Strongly disagree=1, to Strongly agree=5.
with the statement?	=1 if ec=1, 2 or 3; and =0 otherwise.
Stated self-disconnection	Sometimes the emergency credit runs out.
To what extent do you	Strongly disagree=1, to Strongly agree=5.
agree with the statement?	=1 if sd=5, 4 or 3; and =0 otherwise.
Top up timing	
Which statement is most applicable	=0 if "I top up more over winter than summer."
to your spend on gas over the year?	=1 if "I top up roughly the same all year around."
Saving behaviour	When I'm using less gas in warmer months,
To what extent do you agree with?	I like to add any spare cash to my savings.
	Strongly disagree=1 to Strongly agree=5.
	=1 if responses =5 or 4; and 0 otherwise.
Inconvenient	"Pay As You Go makes it easy to pay for my gas."
To what extent do you agree with?	Strongly disagree=1, to Strongly agree=5.
	=1 if responses =1, 2 or 3; and =0 otherwise.
Preferred saving plan	Regular payment throughout the year=1,
	Voluntary savings target=2, Ad-hoc extra payments=3,
	Summer fixed extra payments=4
	Reminder on consumption=5, None=6
Goal achievement	
Low	=1 if "I don't usually achieve my goals" alone or in combination with
	"I usually set-up weekly or monthly goals that I wish to achieve",
	"I usually avoid or delay a task that requires a lot of thinking" or
	"I have difficulties in completing a task that requires organization"
	and =0 otherwise
Medium	=1 if "I usually set-up weekly or monthly goals that I wish to achieve",
	"I usually avoid or delay a task that requires a lot of thinking" and/or
	"I have difficulties in completing a task that requires organization"
	and =0 otherwise.
High	="I usually achieve my goals" or "I usually achieve my goals" with
	"I usually set-up weekly or monthly goals that I wish to achieve").
	and =0 otherwise

Appendix A. Appendix 2

Table A2. Correlations between variables characterizing individual heterogeneity

	1	2	3	4	5	6	7	8
1. Household adults	1							
2. Female	.03	1						
3. Low income	-.25***	.01	1					
4. Medium income	.10***	.02	-.71***	1				
5. High income	.19***	-.05	-.38***	-.38***	1			
6. Basic education	.06**	.11***	.00	-.02	.02	1		
7. Medium education	-.05*	-.05*	-.04	.06**	-.02	-.57***	1	
8. High education	-.01	-.03	-.09***	-.02	.09***	-.30***	-.32***	1
9. Low goal achievement	.00	-.03	-.08	.02	-.01	.03	-.01	-.06**
10. Medium goal achievement	-.06*	.12***	.06*	-.02	-.05	.04	-.03	-.02
11. High goal achievement	.06*	-.09***	-.07**	.03	.06*	-.06*	.04	.04
12. Self-disconnection	.04	.03	.00	.02	-.03	.01	.03	-.02
13. Emergency credit	.07**	.02	-.08***	.09***	-.01	-.02	.05**	.01

Notes: ***, **, * stand for 1, 5, and 10 percent significant levels, respectively.

Appendix B. Appendix 3

Sample question on saving plan choice

The following questions relate to how the payment plan may work and we are looking for your thoughts on what would be the most beneficial / easy to use. Before entering onto the payment plan, you would need to agree to a tailored quote detailing your consumption patterns and spend over the year - this would help you understand how you might manage the cost of your gas with different saving options that suit your lifestyle and income. Some of these options have been listed below and we'd like to know how these sound to you.

The following options are variants of the savings plan. We'd like to know how these saving plans A to E appeal to you. Please rate 1 - 5 where 1 is not appealing and 5 is extremely appealing.

Regular payments throughout year

Based on the summary of your previous year's consumption, you agree to an equal weekly / monthly amount that you commit to paying through the year. Regular equal payments would cover your consumption throughout the year.

Voluntary Savings Target

You chose a target amount that you feel comfortable / confident in saving. You're responsible for meeting this target and it would be up to you whether or not you achieved your target each month. The credit you saved would be used to offset your winter consumption.

Ad-hoc Extra Payments

You make additional payments as and when you can afford to do so. You would not have to nominate a target for your savings but the more you saved, the more of your winter consumption would be offset.

Summer Fixed Extra Payments

You commit to additional fixed payments just during summer months. These additional payments would be calculated on the basis of your winter time gas consumption in the previous year. The extra payments would be used to cover your higher gas payments in the wintertime.

Feedback on Consumption

Without changing your monthly payment plan, you receive regular feedback in the summer about your average gas payments. For example: "Last

year you spent £20 on gas between July and September and you spent £120 on gas between October and December".

From the options listed in the question above which savings plan would you prefer? Choose one option only:

1. Regular payments throughout year
2. Voluntary Savings Target
3. Ad-hoc Extra Payments
4. Summer Fixed Extra Payments
5. Feedback on Consumption
6. None of the above

Table A3. Robustness check: SUBOP and SUBP

	SUBOP		**SUBP**	
	Coefficients		Average marginal effects	
	ec (ordered)	sd (ordered)	ec (redefined)	sd (redefined)
Demographics				
65 and over	-0.537**	-0.411*	-0.533*	-0.721**
	(0.210)	(0.219)	(0.275)	(0.287)
Female	0.033	0.067	-0.056	0.115
	(0.079)	(0.084)	(0.107)	(0.112)
Household adults	0.089**	0.043	0.076	0.061
	(0.035)	(0.037)	(0.048)	(0.049)
Education				
Medium	0.133*	-0.001	0.053	-0.025
	(0.080)	(0.084)	(0.109)	(0.113)
High	0.076	-0.046	0.106	-0.018
	(0.108)	(0.113)	(0.145)	(0.150)
Behavioural characteristics				
Saving behavior	-0.248***	0.017	-0.255***	-0.097
	(0.073)	(0.077)	(0.099)	(0.103)
Top up all year	-0.320**	-0.553***	-0.412**	-0.572***
	(0.131)	(0.147)	(0.168)	(0.198)
Inconvenient	0.142*	0.431***	0.092	0.496***
	(0.080)	(0.083)	(0.106)	(0.108)
Low goal achievement		0.158		0.200
		(0.130)		(0.173)
Medium goal achievement		0.144*		0.286***
		(0.081)		(0.110)
ρ	0.379		0.423	
LL	-2567.3		-852.24	
Wald $\chi^2(11)$	48.51			
Wald $\chi^2(24)$			72.88	
Prob> χ^2	0.000		0.000	
Obs.	905		683	

Notes: SUBOP stands for seemingly unrelated bivariate ordered probit and SUBP stands for seemingly unrelated bivariate probit. In the SUBP, the dependent variables were redefined by dropping the 'neither agree nor disagree option whereas in the SUBOP we did not dropped this option in the dependent variables. Standard errors are in parenthesis. The standard errors in the average marginal effects are calculated by the Delta method. ***, **, * stand for 1, 5, and 10 percent significant levels, respectively. LL stands for log likelihood. Age under 22 and Age to 34, none and low education, low income and high goal achievement were used as reference categories. Age was was used as control but is here omitted (with the exception of 65 and over).

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